CLAIMS

1. An object location system for locating an object having an RFID tag, the object location system comprising:

an object locator, the object locator receiving at least one transmission from the object and determining a general location of the object from the at least one transmission;

an RFID reader, the RFID reader transmitting a plurality of transmitted signals to the RFID tag and receiving a plurality of backscatter-modulated signals from the RFID tag, at least two of the plurality of transmitted signals having a different fundamental frequency; and

a distance calculator, the distance calculator determining a phase for each of the plurality of backscatter-modulated signals from the RFID tag, the distance calculator determining a distance to the RFID tag by determining a rate of change of the phase in the plurality of backscatter-modulated signals with respect to rate of change in the fundamental frequency of the plurality of transmitted signals.

2. The system of claim 1 wherein the object locator determines the general location of the object using received signal strength of the at least one transmission.

3. The system of claim 1 wherein the object locator determines the general location of the object using time difference of arrival of the at least one transmission.

4. The system of claim 1 wherein the object locator determines the general location of the object using angle of arrival of the at least one transmission.

5. The system of claim 1 wherein the object locator includes an 802.11x transceiver.

6. The system of claim 1 wherein the object locator includes a Bluetooth transceiver.

7. The system of claim 1 wherein the object locator includes a WWAN transceiver.

8. The system of claim 1 wherein the RFID tag comprises a multi-mode RFID tag, and wherein the at least one transmission originates from the multi-mode RFID tag.

9. The system of claim 8 wherein the multi-mode RFID tag transmits using an 802.11x protocol transmission in an active mode, and wherein the object locator uses the 802.11x protocol transmission to determine the general location of the object.

10. The system of claim 8 wherein the multi-mode RFID tag transmits using a Bluetooth protocol transmission in an active mode, and wherein the object locator uses the Bluetooth protocol transmission to determine the general location of the object.

11. The system of claim 1 wherein the RFID reader comprises a mobile reader.

12. The system of claim 11 wherein the mobile RFID reader includes a mobile RFID reader RFID tag and wherein the mobile RFID reader tag is utilized to determine a location of the mobile RFID reader.

13. The system of claim 11 wherein the mobile RFID reader transmits to a known location RFID tag to determine a location of the mobile RFID reader.

14. The system of claim 11 wherein the mobile RFID reader communicates using an 802.11x protocol transmission and wherein the object location system uses an 802.11x protocol transmission to determine the general location of the object.

15. The system of claim 11 wherein the mobile RFID reader communicates using an 802.11x protocol transmission and wherein the 802.11x protocol transmission is used to determine a location of the mobile RFID reader.

16. The system of claim 11 wherein the mobile RFID reader communicates using a Bluetooth protocol transmission and wherein the object location system uses the Bluetooth protocol transmission to determine the general location of the object.

17. The system of claim 11 wherein the mobile RFID reader communicates using a Bluetooth protocol transmission and wherein the Bluetooth protocol transmission is used to determine a location of the mobile RFID reader.

18. The system of claim 11 wherein the mobile RFID reader includes a bar-code reader to identify the object from a group of nearby objects.

19. The system of claim 1 wherein the RFID reader continues to transmit additional transmitted signals and receive additional backscatter-modulated signals and wherein the distance calculator continues to determine a phase for each of the additional backscatter-modulated signals received and uses the phase for each additional backscatter-modulated signal to determine the distance from the RFID reader to the RFID tag is until the distance is computed within a specified level of accuracy.

20. The system of claim 1 wherein the rate of change of the phase in the plurality of backscatter-modulated signals with respect to a rate of change in the fundamental frequency of the plurality of transmitted signals is determined by performing a linear trend fit of the phase in the plurality of backscatter-modulated signals versus the fundamental frequency of the plurality of transmitted signals.

21. The system of claim 1 wherein the at least two of the plurality of transmitted signals having a different fundamental frequency have a randomly selected frequency difference.

22. The system of claim 1 wherein the at least two of the plurality of transmitted signals having a different fundamental frequency have a frequency difference determined by selecting a next available frequency channel using a listen before transmit procedure.

23. A method of locating an object having an RFID tag, the method comprising the steps of:

determining a general location of the object using at least one transmission from the object;

transmitting a plurality of transmitted signals from an RFID reader to the RFID tag, the plurality of transmitted signals having a fundamental frequency difference;

receiving a plurality of backscatter-modulated signals from the RFID tag;

determining a phase for each of the plurality of backscatter-modulated signals; and

computing a distance to the RFID tag by determining a rate of change of the phase in the plurality of backscatter-modulated signals with respect to a rate of change in the fundamental frequency of the plurality of transmitted signals.

24. The method of claim 23 wherein the step of determining a general location of the object comprises using received signal strength of transmissions.

25. The method of claim 23 wherein the step of determining a general location of the object comprises using time difference of arrival of transmissions.

26. The method of claim 23 wherein the step of determining a general location of the object comprises using angle of arrival of transmissions.

27. The method of claim 23 wherein the step of determining a general location of the object comprises using 802.11x transmissions.

28. The method of claim 23 wherein the step of determining a general location of the object comprises using Bluetooth transmissions.

29. The method of claim 23 wherein the step of determining a general location of the object comprises using WWAN transmissions.

30. The method of claim 23 wherein the RFID tag comprises a multi-mode RFID tag.

31. The method of claim 30 wherein the multi-mode RFID tag transmits using an 802.11x protocol transmission in an active mode, and wherein the step of determining a general location of the object using at least one transmission from the object comprises using an 802.11x protocol transmission from the multi-mode RFID tag to determine the general location of the object.

32. The method of claim 30 wherein the multi-mode RFID tag transmits using a Bluetooth protocol transmission in an active mode, and wherein the step of determining a general location of the object using at least one transmission from the object comprises using a Bluetooth protocol transmission to determine the general location of the object.

33. The method of claim 23 wherein the RFID reader comprises a mobile reader.

34. The method of claim 33 wherein the mobile RFID reader includes a mobile RFID reader RFID tag, and further comprising the step of using the mobile RFID reader tag to determine a location of the mobile RFID reader.

35. The method of claim 33 further comprising the step of transmitting from the mobile RFID reader to a known location RFID tag to determine the location of the mobile RFID.

36. The method of claim 33 wherein the mobile RFID reader comprises communicates using an 802.11x protocol transmission and wherein the step of determining a general location of the object using at least one transmission from the object comprises using an 802.11x protocol transmission is to determine the general location of the object.

37. The method of claim 36 further comprising the step of using an 802.11x protocol transmission to determine a location of the mobile RFID reader.

38. The method of claim 33 wherein the mobile RFID reader comprises communicates using a Bluetooth protocol transmission and wherein the step of determining a general location of the object using at least one transmission from the object comprises using a Bluetooth protocol transmission from the mobile RFID reader to determine the general location of the object.

39. The method of claim 38 further comprising the step of using a Bluetooth protocol transmission to determine a location of the mobile RFID reader.

40. The method of claim 23 wherein the steps of transmitting a plurality of transmitted signals, receiving a plurality of backscatter-modulated signals, and determining a phase in the plurality of backscatter-modulated signals comprises transmitting, receiving and determining a phase for additional transmitted signals and backscatter-modulated signals until the step of computing the distance to the RFID tag determines the distance within a specified level of accuracy.

41. The method of claim 23 wherein the step of computing a distance to the RFID tag by determining a rate of change of the phase in the plurality of backscatter-modulated signals with respect to a rate of change in the fundamental frequency comprises performing a linear trend fit.

42. The method of claim 23 wherein the plurality of transmitted signals have a randomly selected fundamental frequency difference.

43. The method of claim 23 wherein the plurality of transmitted signals have a fundamental frequency difference selected by selecting a next available frequency channel using a listen before transmit procedure.

44. The method of claim 23 wherein the step of computing a distance to the RFID tag by determining a rate of change of the phase in the plurality of backscatter-modulated signals with respect to a rate of change in the fundamental frequency comprises performing a linear trend fit.

45. The method of claim 23 wherein the step of determining a phase for each of the plurality of backscatter-modulated signals comprises unwrapping relative phase difference measurements to result in a substantially linear phase trend.

46. The method of claim 23 wherein the step of transmitting a plurality of transmitted signals from the RFID reader to the RFID tag comprises transmitting from an array of RFID readers, and wherein the step of receiving a plurality of backscatter-modulated signals from the RFID tag comprises receiving the plurality of backscatter-modulated signals at the array of RFID readers, and wherein the step of computing a distance to the RFID tag comprises computing a distance from the RFID tag to each of the array of RFID readers.

47. The method of claim 23 wherein the step computing a distance to the RFID tag by determining a rate of change of the phase in the plurality of backscatter-modulated signals with respect to a rate of change in the fundamental frequency of the plurality of transmitted signals comprises using at least three determined phases and at least three fundamental frequencies to calculate the rate of change.

48. An object location system for locating an object, the object location system comprising:

an object locator, the object locator receiving at least one transmission from a multi-mode RFID tag operating in an active mode on the object, the object locator determining a general location of the object from the at least one transmission from the multi-mode RFID tag;

an array of RFID readers distributed around an area, a plurality of the array of RFID readers transmitting at least three transmitted signals to the multi-mode RFID tag, the plurality of the array of readers selected from the array of RFID readers based on the general location of the object, each of the plurality of the array of RFID readers receiving at least three backscatter-modulated signals from the multi-mode RFID tag, wherein the at least three transmitted signals from each RFID reader have a fundamental frequency with a fundamental frequency difference; and

a distance calculator, the distance calculator determining a phase of the at least three backscatter-modulated signals received at each RFID reader, the distance calculator determining a distance from each RFID reader by performing a linear trend fit of the phase in the at least three backscatter-modulated signals and the fundamental frequency of the at least three transmitted signals to determine a rate of change of the phase with respect to a rate of change of the fundamental frequency.

49. The system of claim 48 wherein at least one of the array of RFID readers comprises a mobile reader.

50. The system of claim 49 wherein the mobile RFID reader includes a mobile RFID reader RFID tag and wherein the mobile RFID reader tag is utilized to determine a location of the mobile RFID reader.